Hemodialysis versus peritoneal dialysis in resource-limited settings

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Abstract: PURPOSE OF REVIEW To assess the use, access to and outcomes of hemodialysis and peritoneal dialysis in low-resource settings. RECENT FINDINGS Hemodialysis tends to predominate because of costs and logistics, however services tend to be located in larger cities, often paid for out of pocket. Outcomes of dialysis-requiring acute kidney injury and end-stage kidney disease may be similar with hemodialysis and peritoneal dialysis, and therefore choice of therapy is dominated by availability, accessibility and patient or physician choice. Some countries have implemented peritoneal dialysis-first policies to reduce costs and improve access, because peritoneal dialysis requires less infrastructure, can be scaled up more easily and can be cheaper when fluids are manufactured locally. SUMMARY Access to both hemodialysis and peritoneal dialysis remains highly inequitable in lower-resource settings. Although challenges associated with dialysis in low-resource settings are similar, and there are more adults who require dialysis in low-resource settings, addressing hemodialysis and peritoneal dialysis needs of children in low-resource settings requires attention as the global inequities are greatest in this area. Lower-income countries are increasingly seeking to improve access to dialysis through various strategies, but meeting the costs of the entire dialysis population continues to be a major challenge.

DOI: https://doi.org/10.1097/MNH.0000000000000455

Hemodialysis versus peritoneal dialysis in resource-limited settings

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To assess the use, access to and outcomes of hemodialysis and peritoneal dialysis in low-resource settings.

Recent findings
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Summary
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Keywords
equity, hemodialysis, low-resource settings, peritoneal dialysis-first, peritoneal dialysis

INTRODUCTION

One hundred and thirty-eight of 189 World Bank member countries are defined as low-income and middle-income, hosting 87% of the world's population [1]. In 2010, 2.6 million people worldwide received renal replacement therapy (RRT), 62% of whom reside in high, 31% in upper-middle income, 6.6% in lower-middle income, and 0.6% in low-income countries demonstrating enormous global inequities in access to RRT [2]. In India, only 10% of the estimated 220 000–275 000 incident patients with end-stage kidney disease (ESKD) receive dialysis, and in China, the 272 000 patients receiving dialysis represent only 20% of those who require it [3,4]. In Africa, fewer than 130 000 patients receive dialysis, of whom 75% live in North Africa (personal communication AN). In 2010, it was estimated that between 2.3 and 7 million people worldwide died without access to RRT [2]. Although transplantation is the optimal therapy for RRT, given improved quality of life (QOL), survival and lower costs, not all patients requiring dialysis are eligible for transplantation, transplantation is not available in all countries, and the global shortage of organs inherently limit access to this strategy [5]. The majority of patients with ESKD therefore rely on dialysis for survival.

USE OF HEMODIALYSIS VERSUS PERITONEAL DIALYSIS IN LOW-RESOURCE SETTINGS

Globally, over 80% of patients with ESKD receive hemodialysis [6]. In most high-income settings

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Curr Opin Nephrol Hypertens 2018, 27:000–000
DOI:10.1097/MNH.0000000000000455

KEY POINTS

- Hemodialysis is the predominant form of dialysis in low-resource settings because of cost and logistical challenges associated with peritoneal dialysis.
- Acute peritoneal dialysis is a well tolerated and effective therapy for dialysis-requiring acute kidney injury in low-resource settings.
- Peritoneal dialysis is the preferred acute and chronic dialysis modality for children in low-resource settings.
- Peritoneal dialysis-first policies are more cost-effective than hemodialysis-first policies when costs can be contained.
- Peritoneal dialysis is more scalable than hemodialysis and therefore may be more equitable for patients requiring chronic dialysis in low-resource settings.

peritoneal dialysis is cheaper than hemodialysis; however, the proportion of patients receiving peritoneal dialysis is low [7▪▪]. Many factors contribute to the low utilization of peritoneal dialysis including physician and patient preference, patient comorbidities, lack of knowledge or experience, greater experience with hemodialysis, late referral to nephrology, physician remuneration and so on. In South Africa, for example, for multiple reasons, in 2013, the ratio of hemodialysis/peritoneal dialysis in the public sector was 48%/26% and in the private sector was 84%/8% [8]. Peritoneal dialysis is only available in 29% of low-income and 68% of lower-middle income countries compared with 97 and 100% in upper-middle and high-income countries [9]. In countries where a peritoneal dialysis-first policy has been instituted, the proportions of ESKD patients on peritoneal dialysis are higher: Hong Kong 72%, Mexico 45%, Thailand 25% [6,10]. In sub-Saharan Africa, among patients able to access dialysis, 90 and 84% of adults and 80 and 46% of children with acute kidney injury (AKI) and ESKD, respectively, received hemodialysis [11▪,12▪]. In lower-income South East Asian countries, 80–95% of ESKD patients receive hemodialysis and 75% of ESKD patients receive hemodialysis in Latin America [4,13].

Clinically, outcomes of patients with ESKD and AKI treated with either hemodialysis or peritoneal dialysis are generally similar, and therefore the choice of therapy comes down to patient or physician decision and availability [11▪,12▪,14]. Few studies have examined QOL in peritoneal dialysis versus hemodialysis patients in low-resource settings. Two South African studies found no difference in overall QOL between hemodialysis and peritoneal dialysis, although peritoneal dialysis patients scored higher for work status, but lower for body image and peer support/social interaction [15,16]. The advantages of peritoneal dialysis, that would favor improving equity in access to dialysis and scale-up of dialysis coverage, especially for low and lower-middle income countries (LLMICs), are outlined in Table 1 [7▪▪,14–21,22▪,23▪,24▪▪,25,26] and discussed in detail elsewhere [7▪▪,27].

DIALYSIS FOR CHILDREN IN LOW-RESOURCE SETTINGS

Among children on RRT, 80% reside in North America, Europe and Japan, where access is practically universal [28]. In lower-income settings, children have less access to RRT than adults because of economic pressures, lack of expertise, and infrastructure and sex inequities [11▪,12▪,28,29]. Dialysis is a demanding and challenging treatment for children with AKI and ESKD. In LLMIC, the existence and sustainability of paediatric dialysis largely depends on the development of adult dialysis programmes, and children may be cared for by adult nephrologists [30]. Paediatric nephrology centres are located only in few major cities [31]. While few children are cared for by adult dialysis centres in smaller towns, in general, children and infants from remote regions cannot obtain long-term dialysis.

Dialysis for ESKD

Brazil, which shares a similar diversity in socioeconomic, cultural and regional profiles with Asia, reported a low prevalence of children on dialysis [32]. In India, nearly one quarter of children with chronic kidney disease (CKD) present with ESKD at the time of diagnosis [33]. Presentation with life-threatening complications impacts the modality of dialysis chosen with a preference towards emergency hemodialysis. Globally, over two decades, the developed world has witnessed significant improvement in mortality of children on dialysis along with decreased waiting time for transplantation and a slight increase in the overall use of hemodialysis in both younger and older children. Among LLMIC, though there are no clear long-term data, chronic hemodialysis is often the only option [34,35]. In India, peritoneal dialysis is preferred especially in young children because of advantages outlined in Table 1. Unique challenges exist in dealing with the perceptions of families where those from poorer backgrounds may be intimidated by the responsibility of peritoneal dialysis and prefer hemodialysis, although this trend is shifting and the ratio of chronic peritoneal dialysis to hemodialysis is now 10 : 1 in

Table 1. Potential relative advantages and disadvantages of peritoneal of peritoneal dialysis and hemodialysis in low-resource settings[a,b]

	Relative advantages	Relative disadvantages	Barriers
PD	**Patient perspective** Possible in remote locations Reduced dialysis time Better attendance at school Greater ability to work Possible improved QOL Possible improved QOL of caregivers Permits dialysis patients to be care givers for others Fewer fluid and dietary restrictions **Nephrologist/HCW perspective** Does not require full-time highly trained nephrology personnel Reduced reliance on infrastructure, technology, electricity Better preservation of residual renal function Preservation of veins for vascular access Solutions and catheters can be improvised for acute PD Easier to train and mentor people remotely Possibly higher delivered dose of dialysis under cost constraints **Health systems perspective** Lower costs and higher QALY than HD (e.g. Indonesia) Easier to scale up	**Patient perspective** (Fear of) infection risk – may limit social interactions Requires adequate home environment Negative body image, impact on sexual function Difficult to do PD exchanges while at work Some patients reported greater limitations in QOL Less peer support between dialysis patients, especially if remote **Nephrologist/HCW perspective** Unavailability of small-sized catheters and fluid bags Worse outcomes if malnutrition Significant loss of proteins through peritoneum in young children PD eventually fails and HD will be required at some stage if transplantation not possible Lack of expertise in catheter placement Need patient autonomy or may require on-going assistance for patients **Health systems perspective** Require training and culture shift Requires reliable availability of supplies Logistical difficulties delivering fluids remotely (including illegal 'levies') Requires back-up HD for failed PD	**Patient perspective** High cost of supplies Costs often catastrophic Poor education Poor health literacy Some comorbidities Patient hygiene Environmental hygiene Roads and distance when need to seek help **Nephrologist/HCW perspective** Lack of knowledge or confidence with PD among nephrologists and patients Lower reimbursement than HD Rapid staff turnover **Health systems perspective** Lack of policies regarding dialysis High cost of supplies Not cost-effective PD not available in some countries Lack of local manufacture of PD fluids Roads and distance when need to seek help Even if dialysis costs are covered, medication and at times supplies are not covered mandating on-going out-of-pocket expenditure
HD	**Patient perspective** Patients feel safe in centre Patients less concerned about infections May be preferable for some patient groups, for example, with diabetes More peer support from patients **Nephrologist/HCW perspective** Higher dose of dialysis possible Nephrologists more confident with HD than with PD Currently the only modality available in some countries **Health systems perspective** Twice weekly dialysis may be an acceptable compromise to reduce costs	**Patient perspective** Time-consuming Less convenient to continue work or schooling Over-medicalization of dialysis Multiple fold greater out-of-pocket expenditure for non-medical costs (e.g. transportation) Higher indirect costs (e.g. loss of income) **Nephrologist/HCW perspective** Dependent on technology More difficult in children and babies Requires reliable safe vascular access More rapid loss of renal function **Health systems perspective** Requires full-time highly trained personnel Requires reliable availability of supplies, staff and infrastructure	**Patient perspective** Cost of transportation Greater costs of blood testing Costs often catastrophic **Nephrologist/HCW perspective** Lack of adequate training at all levels Rapid staff turnover Slots limited by number of functioning machines and staff Rapid loss of vascular access possibilities due to reliance on temporary catheters because of cost Lack of vascular surgery expertise Requires dedicated space, electricity, water **Health systems perspective** Lack of policies regarding dialysis Location of dialysis units generally only in more populated cities Lack of oversight of private dialysis activities Cost of dialysis supplies, infrastructure, staff Even if dialysis costs are covered, medication and at times supplies are not covered mandating on-going out-of-pocket expenditure

HCW, healthcare worker; HD, hemodialysis; PD, peritoneal dialysis; QALY, quality adjusted life-year.
[a]Information presented in the table presumes some governmental oversight and policy development around provision of dialysis.
[b]PD and HD are considered relatively equivalent in terms of clinical outcomes, which are not itemized in this table. Catastrophic costs – defined as costs pushing households further into poverty, more than 40% of household's annual income after covering basic needs [7▪▪,14,15,17,18,19–21,22▪,23▪,24▪▪,25,26].

Bangalore. Denial, abrupt discontinuation, high rates of infectious complications and sudden deaths remain problems in young children on chronic dialysis.

In older children aged above 10 years, in the United States, 52% initiate RRT with hemodialysis, 27% with peritoneal dialysis and 21% with transplants [36]. In contrast to the potential benefit of social interaction for children on hemodialysis in the west, children in low-resource settings do not have this advantage as they receive hemodialysis in adult units. Most children on chronic hemodialysis have temporary vascular access due to cost constraints and limited expertise in constructing fistulas in younger children. QOL of children on hemodialysis is further restricted by lack of access to school or extracurricular activities. A study from Taiwan found similar survival among children on chronic hemodialysis compared with peritoneal dialysis; however, such data in lower-resource settings are largely absent [37].

Experience from India, as from other LLMIC, reveals that children on peritoneal dialysis, especially with low body weight (<15 kg), have severe comorbidities like growth retardation and cardiovascular disease [28]. Nearly 40–50% of children on chronic peritoneal dialysis in India proceed with transplantation, and the rest either discontinue, succumb to complications or get burnt out sustaining inadequate dialysis. Rates of peritonitis are very high in these children as most opt for manual rather than automated peritoneal dialysis and belong to rural or low socioeconomic groups (personal communication AI). Manual peritoneal dialysis poses unique challenges as dialysis adequacy is often suboptimal due to compromises in peritoneal dialysis duration per day (14–17 h) limited by cost and logistics. Lactate-based solutions are used due to the unavailability of bicarbonate-based fluids. Continued efforts towards financial support and reinforcement of training in the caregivers become crucial components of care.

Dialysis for acute kidney injury

With regard to the choice of dialysis for AKI, surveys reveal differences in the modality preference and factors governing such choices between the higher and lower-income settings [38▪,39,40]. In striking contrast to the west, AKI in the tropics and LLMIC is secondary to sepsis, dehydration, infections and toxins, and is associated high mortality rate and risk for long-term renal consequences [41,42]. Acute peritoneal dialysis is the most common and preferred modality for AKI in LLMICs due to the ease of technique, low cost and feasibility in resource-limited settings, although not routinely available [17,40,43–45]. Recent consensus guidelines for acute peritoneal dialysis are an excellent resource describing low-cost adaptations to catheters and solutions where traditional peritoneal dialysis supplies are not obtainable [18]. Such techniques have been successfully used with acceptable mortality rates [46]. A recent review highlights the advantages and multiple challenges of acute peritoneal dialysis or infants in children with AKI [47]. Flexible catheters are generally recommended over rigid catheters if possible and expedient [18]. In LLMIC countries, 68.5% of clinicians preferred peritoneal dialysis over other dialysis therapies, whereas in higher-income countries, clinicians favoured hemodialysis (72%) or continuous renal replacement therapy (CRRT) (24%) in infants [38▪]. The survey also highlights the fact that although the use of CRRT differed between lower and higher-income countries (33.3 versus 60%), use of sustained low-efficiency dialysis was similar (25 versus 20%) [38▪]. In India, 83% opted for acute peritoneal dialysis, 17% for hemodialysis and only 5–10% could offer CRRT [48]. Acute peritoneal dialysis is the only modality used even in the best of centres LLMIC as newer modalities like the Newcastle infant dialysis and ultrafiltration system and cardio-renal pediatric dialysis emergency machine are generally out of reach to the common neonate. [38▪,49] Not all children in LLMIC receive dialysis when required [12▪]. In most low-resource settings, apart from sex bias, there is delay in diagnosis and referral of children with AKI to higher levels of care. Efforts with a special focus on the low-resource settings by the International Society of Nephrology and the Saving Young Lives programme are training physicians and nurses to perform acute peritoneal dialysis and lives have been saved [46,50]. An innovative online training program has also been launched with good uptake [51]. Interestingly, 57% of those using the program were nurses demonstrating that peritoneal dialysis practice is not restricted to nephrologists.

BARRIERS TO DIALYSIS IN LOW-RESOURCE SETTINGS

Access to dialysis is increasing in LLMIC; however, many challenges exist at both individual and health systems levels, which result in inequitable access to dialysis and high mortality rates among patients with ESKD and dialysis-requiring AKI (Table 2) [3,11▪,12▪,52]. Lack of strategies for prevention of CKD or AKI, lack of awareness among communities and healthcare workers, lack of screening in high-risk individuals, lack of access to essential medications for early treatment and prevention of

Table 2. Outcomes in adults and children with dialysis-requiring renal failure in sub-Saharan Africa[a]

	AKI		ESKD		
	Adults	Children	Incident adults	Prevalent adults	Children
Access to dialysis	33%	66%	51%	NA	61%
Mortality without dialysis when needed	86%	73%	96%	NA	95%
Mortality with dialysis	30%	30%	88%	16%	36%
Stopped dialysis although needed	NR	NR	84%	5%	49%
Left against medical advice or lost to follow up	12%	9%	27%	8%	26%

NA, not applicable; NR, not reported.
[a]Data reflect pooled outcomes from varying numbers of studies which reported the specific outcomes (see original articles for details [11▪,12▪]).

progression or AKI and CKD, late presentations, lack of training and capacity building, lack of infrastructure for dialysis and high reliance on out-of-pocket payments (OPPs), are all important determinants of patient outcomes, as highlighted in Fig. 1. Apart from financial constraints, social and religious hurdles also exist in some regions. Steps to address some of these barriers have been initiated by the Committee of Japanese Society of Dialysis and Transplantation to Support Dialysis Staffs in the Asian Developing Countries in 2015 [53].

Cost of dialysis

Chronic dialysis, in the form of hemodialysis or peritoneal dialysis, demands high-level funding and expenditure that remains a major challenge for LLMICs, as many do not have government schemes or insurance support to sustain long-term RRTs. Accessibility of dialysis tends to vary with country gross domestic product (GDP) per capita, although some countries with lower GDPs have committed to universal coverage for RRT [4,52,54]. Public health expenditure also impacts outcomes in patients receiving RRT [55▪]. Health insurance coverage and universal coverage for dialysis in many LLMICs are low [3,4,52,56].

Little data exist on the relative costs of hemodialysis and peritoneal dialysis in LLMICs from both provider and societal perspectives [57,58]. In many LLMICs, in contrast to higher-income countries, peritoneal dialysis tends to be more expensive than hemodialysis because of the need to import peritoneal dialysis fluids and supplies, legal and illegal taxes and levies imposed during import and delivery of supplies and consequently the relatively small market in some regions [7▪▪,19,57,59▪▪]. Analysis of the respective proportions of the total costs for hemodialysis and peritoneal dialysis in Brazil, where peritoneal dialysis was overall marginally cheaper, included direct medical-hospital costs 82.3 and 86.5%, direct nonmedical costs 5.3 for and 3.7%, and indirect costs 12.4 and 9.8% [20]. Loss of productivity accounted for significant costs [20]. In Iran, the costs for diagnostic tests, drugs, hospitalization and so on were higher for hemodialysis compared with peritoneal dialysis [60]. In South Africa, despite dialysis being provided by the state, transport costs for families of children on hemodialysis amounted to 27.1% of household income compared with 4.9% for those on peritoneal dialysis [21].

Extension of coverage for dialysis in lower-resource settings

Increasingly, LLMICs are providing dialysis in the public sector (e.g. Kenya, India, Sudan), but the practicalities and persistent requirements for out-of-pocket (OOP) spending remain barriers to effective universal access [3]. Families are often faced with an impossible decision of whether to incur catastrophic expenditure (defined as an expenditure >10% of household income on healthcare) or to let a loved one die, and often experience both [22▪].

In Ghana, for example, the National Health Insurance Scheme (34% of the population are active members) pays for the cost of acute dialysis up to USD 265, but does not cover chronic dialysis, which costs USD 65 per treatment [61,62]. Chronic peritoneal dialysis is not available in Ghana, and children rarely obtain chronic dialysis [61]. In Senegal, 600 patients receive chronic dialysis, of whom 60 receive peritoneal dialysis (automated and ambulatory) [63]. Among the dialysis patients, 53% are supported by the government including those on peritoneal dialysis, which is entirely covered. In the private sector, a hemodialysis session costs 130 USD. In the public sector, dialysis supplies are obtained through the National Pharmacy Supply, through international tenders, which last 2 years, and therefore permit regular re-negotiations. Annual costs per patient are 13.650 USD for peritoneal dialysis and 18 000 USD for hemodialysis (personal communication AN). In India, despite the relatively low

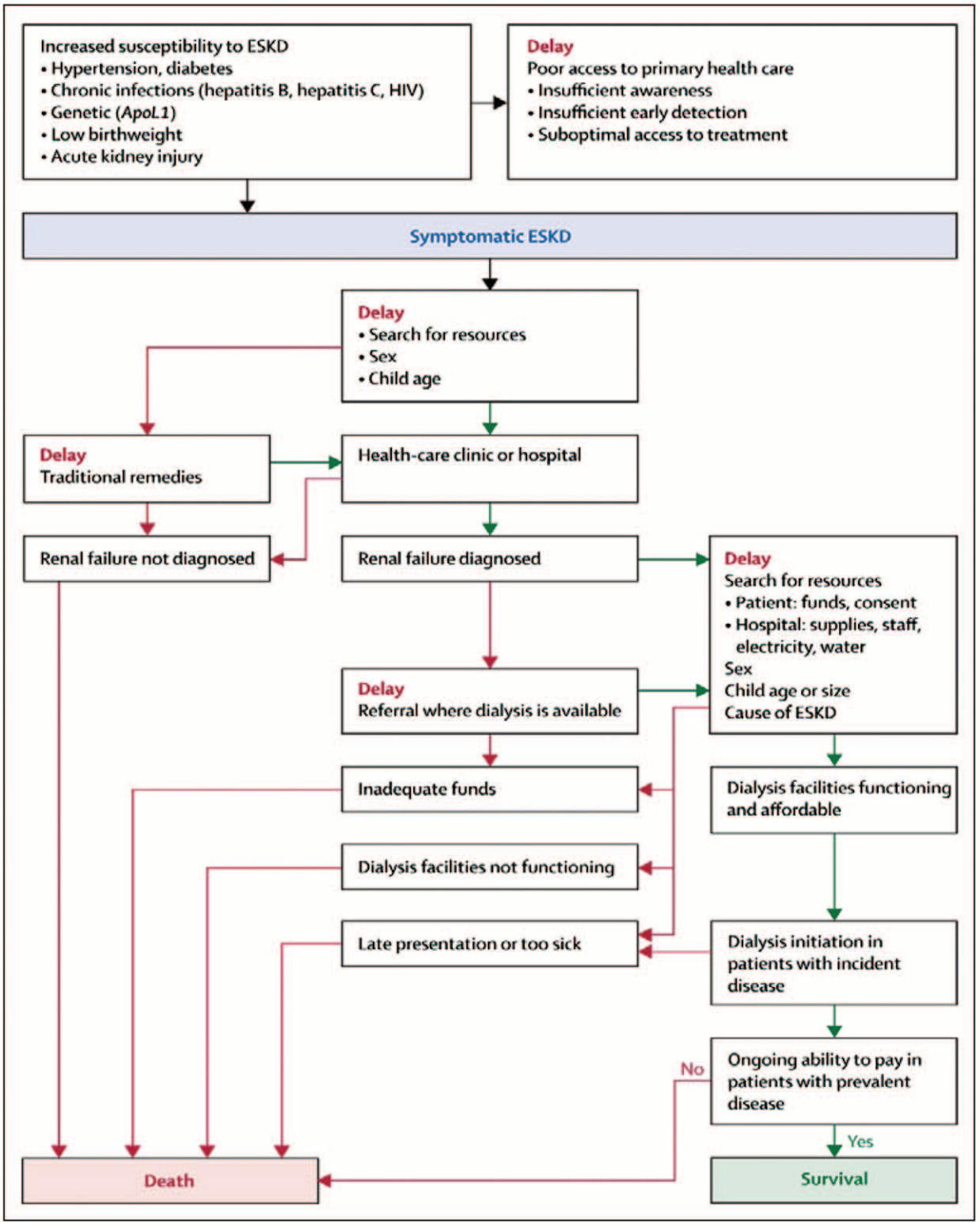

FIGURE 1. Illustration of individual and health system barriers which contribute to reduced access to dialysis and mortality in patients with dialysis-requiring kidney failure in low-resource settings [11▪]. Copyright © 2017 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY-NC-ND license.

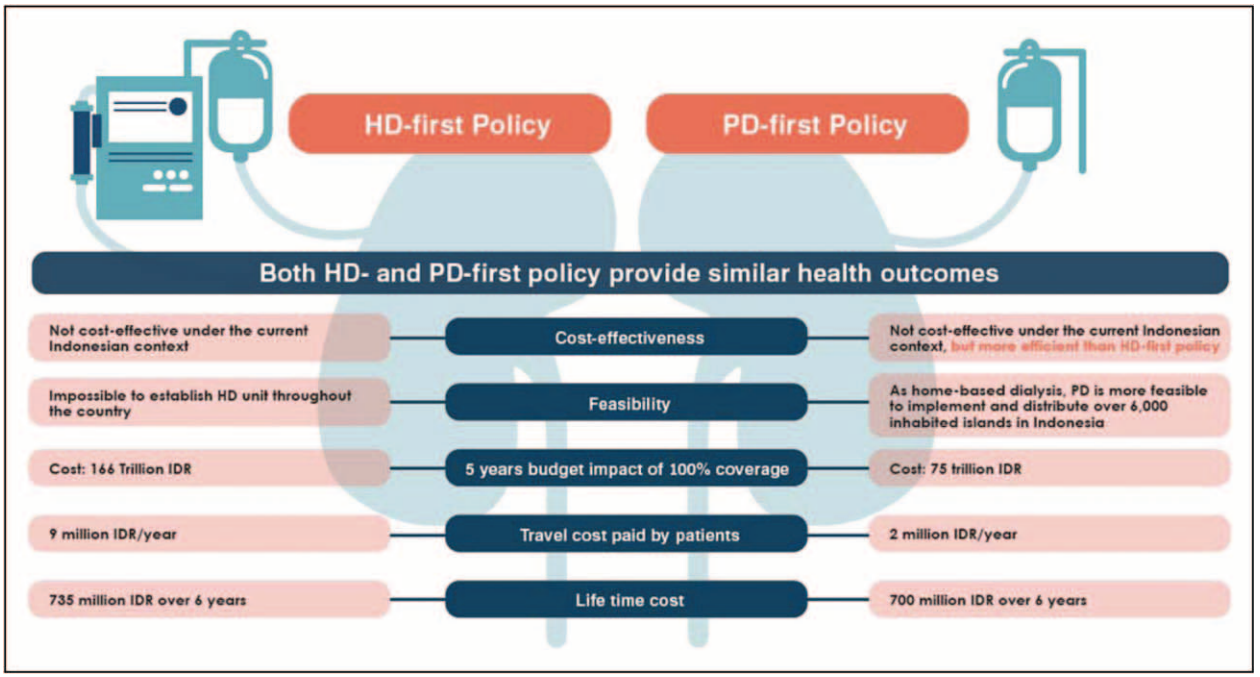

FIGURE 2. Health technology assessment (HTA) for renal dialysis for end-stage renal disease in Indonesia. Compares with supportive care, all dialysis is not cost-effective; however, if lives are to be saved, peritoneal dialysis provides a more sustainable and affordable policy solution for end-stage renal disease. HTA are highly context-specific and therefore each country must take into account their local circumstances, disease burden, costs and values to determine how best to sustainably and equitably address management of end-stage kidney disease and provision of dialysis. The figure is reproduced with permission from [10]. The full policy Brief is available at http://www.hitap.net/wpcontent/uploads/2016/10/PB_RRT_Web_10OCT16.pdf.

penetration of peritoneal dialysis (18–20% of dialysis), local fluid manufacture and innovative insurance schemes have made peritoneal dialysis more affordable [4]. The 'Once-in-a-Lifetime Payment Scheme' provides life-long access to supplies for chronic peritoneal dialysis (including home delivery) for a total fee of 15 500 USD payable over 3 years [4]. Among the peritoneal dialysis patients, 46% in South India belong to this scheme. In addition, a supplemental 'Peritoneal Dialysis Suraksha Insurance' costing 58 USD per year can be obtained and provides full coverage for episodes of peritonitis, including catheter replacement and temporary hemodialysis [4]. Despite attempts to improve access, many patients in LLMIC will remain without access to dialysis, unless there is true universal coverage [22▪]. Most countries cannot afford providing universal access to dialysis, especially while being faced with many other health challenges that may have priority. Governments should develop transparent policies governing access to limited dialysis services, and over time, incrementally increase access as the country progresses towards achievement of universal health coverage [22▪,52,64,65].

An example of a systematic approach to determining the optimal dialysis strategy is the Health Technology Assessment (HTA) conducted in Indonesia [10,23▪]. The value for money and budget impact of offering a hemodialysis-first or a peritoneal dialysis-first policy was compared. The peritoneal dialysis-first policy was more cost-effective and has a lower cost-per-quality adjusted life-year than hemodialysis (Fig. 2). A similar approach conducted previously in Thailand permitted the government to gather pertinent information at the planning stage, which facilitated negotiations up front and allowed the country to retain some control over pricing and to develop the necessary sustainable infrastructure [66]. A peritoneal dialysis-first policy could be interpreted as an infringement of a patient's autonomy to choose, but from the societal perspective this permits more patients to access dialysis without inferior outcomes and therefore is justifiable [66].

OVERCOMING OTHER BARRIERS TO DIALYSIS IN LOW-RESOURCE SETTINGS

As outlined in the guidelines for peritoneal dialysis in AKI, use of alternative tubing as dialysis catheters and of 'home-made' dialysis solutions have improved access to peritoneal dialysis in low-income settings [18]. Reducing the frequency of

hemodialysis to twice a week when clinically tolerable reduces costs and may negatively impact outcomes [24▪▪]. Emphasis on local fluid manufacture (national or regional) in LLMICs would reduce the costs of peritoneal dialysis further [7▪▪]. Better understanding of local burdens of CKD and AKI would permit better prevention, early diagnosis and treatment, and reduce the need for dialysis [39,67]. Overcoming geographical, sex and cultural barriers requires a multi-sectoral approach to improving access to health services in general and to dialysis in particular.

CONCLUSION

Ultimately, transplantation is the most cost-effective form of RRT and should be actively developed in parallel to any dialysis programme [68]. Peritoneal dialysis is generally a more cost-effective and scalable from of dialysis which is underutilized. A policy approach is required to develop and implement strategies to improve equity in access to and quality of dialysis in low-resource settings, to foster integration between government, non-governmental organizations, private sector and the international nephrology community, and through development of regional training programmes and support for local research, to understand local needs and develop local sustainable and equitable solutions to improve access to kidney care [39].

Acknowledgements

None.

Financial support and sponsorship

No funding was required for this work.

Conflicts of interest

The authors report no conflicts of interest.

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- ▪▪ of outstanding interest

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